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# PATENT SPECIFICATION

DRAWINGS ATTACHED

1031640



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## COMPLETE SPECIFICATION

### Improvements in or relating to the production of Tubes

We, IMPERIAL METAL INDUSTRIES (KYNOCHE) LIMITED, a British Company, of Imperial Chemical House, Millbank, London, S.W.1, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The present invention relates to the production of tubes and is particularly concerned with improvements in or relating to the production of bent tubes of helically wound fibre-reinforced plastics material.

The object of the present invention is to provide a method of making a bent tube of helically wound fibre-reinforced plastic material of the kind which does not include the difficult operation of winding reinforcing material around a bent tube.

According to the present invention a method of making a bent tube of helically wound fibre-reinforced plastics material comprises maintaining a straight non-porous cylindrical shell of deformable material in rigid condition providing the shell with at least one external layer of helically wound filament, arranging for each filament layer to be impregnated with a curable plastics material, causing the shell to assume a non-rigid condition, bending the shell while maintaining therein sufficient fluid pressure to sustain its circular cross-section during the bending operation, and curing said curable plastics material after the shell has been fully bent, while maintaining said fluid pressure.

Preferably the shell comprises a thermoplastic material which is maintained at a temperature at which it is rigid during winding and raised to a temperature at which it is non-rigid during bending. Alternatively, the shell may be made of a permanently non-rigid material, such as rubber, which is internally supported by a rigid former during winding, the former being removed prior to bending the shell.

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If the shell is required as a lining in the finished bent tube, it can be made from thermoplastic material, such as polyvinyl chloride. However, if no lining is required in the finished bent tube, the shell may be made from, say, rubber for easy removal from the finished tube.

The curable plastics material may be any suitable resin such as an epoxy-type cold or hot curing resin, and impregnation may be achieved by passing the filament through the curable plastics material immediately before winding, coating the non-porous shell before winding, impregnating the completed layer or layers of filament, or winding with pre-impregnated filament.

Preferably at least three layers of filament are wound on to the shell to form a triple helical pattern; for instance, two layers may be wound at a helical angle of 45°, the angles of the layers being in opposite senses and one layer at an angle closely approaching 90° to the axis of the shell.

On bending the shell, the filaments in the wound layers re-orientate themselves so that each turn of filament occupies the geodesic path appropriate to its position along the bent tube.

The preferred method of bending the non-porous shell is by applying a couple or turning moment to each end. This makes the provision of a range of bending formers unnecessary, the radius and angle of bend depending upon the length of unsupported shell and the turning moment applied. Furthermore, with the preferred method of bending there is no need for sticky uncured plastics materials to come into contact with the bending apparatus.

The fluid pressure within the non-porous shell can be obtained by fitting a bored plug into each end of the shell and passing fluid through it at an experimentally ascertained pressure.

The pressurising fluid may be heated, so that it can be used both to cure the curable

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plastics material and, if necessary, to render the shell non-rigid before bending.

The method of the invention will now be described, by way of example only, with reference to the diagrammatic drawing accompanying the provisional specification, wherein:—

Figure 1 illustrates a tube of polyvinyl chloride overwound with three layers of filament;

Figure 2 illustrates the wound tube closed at each end with a centrally perforated plug;

Figure 3 illustrates the plugged tube with the plugs mounted in the arms of a bending apparatus; and

Figure 4 illustrates the tube of Figure 3 after a couple has been applied to the arms of the bending apparatus.

A rigid cylindrical tube 1 of polyvinyl chloride of length 18 ins., thickness 0.125 in. and internal diameter 1.5 in. was helically wound with a continuous glass filament, comprising multi-strand glass rovings, so as to form three layers of filament, the winding angle for the first two layers being 45° and for the third layer 88° to the axis of the tube, the first two layers being wound in opposite senses. The filament layers were then impregnated with a hot-curable or hot-setting epoxy resin so as to form glass fibre-reinforced epoxy resin structure 2. A plug 3 having a bore 4, was inserted into each end of tube 1 and secured firmly by a clamping ring 5. Each plug 3 was then located in the central supporting tube of a turning arm 6 of a bending apparatus 7. Hot liquid at a temperature of 90° C and a pressure of 40 lbs/sq.in. was then passed through tube 1 by way of bores 4 while opposed turning moments were applied to turning arms 6. This caused the polyvinyl chloride to soften and the unsupported length of tube 1 to bend gradually, the turning moments being maintained until the opposite ends of tube 1 were at an angle of 90°. Turning arms 6 were then maintained in the positions shown in Figure 4 and pressurising liquid at the aforementioned temperature and pressure passed through tube 1 until the epoxy resin was completely cured. Plugs 3 were then removed.

The product consisted of a cured epoxy resin glass-reinforced tube having a firmly bonded liner of polyvinyl chloride and a bend of 90°.

It will be appreciated that to produce a helically wound layer of filament upon a bent tube would entail deriving and executing a complex winding scheme. In contrast to

this, using the method of the present invention, commercially available winding apparatus may be used to wind a standard pattern on to a straight shell, the more complex inter-arrangement of the turns of filament required for a bent tube being produced automatically during subsequent bending of the shell.

#### WHAT WE CLAIM IS:—

1. A method of making a bent tube of helically wound fibre-reinforced plastics material comprising maintaining a straight non-porous cylindrical shell of deformable material in rigid condition, providing the shell with at least one external layer of helically wound filament, arranging for each filament layer to be impregnated with a curable plastics material, causing the shell to assume a non-rigid condition, bending the shell while maintaining therein sufficient fluid pressure to sustain its circular cross-section during the bending operation, and curing said curable plastics material after the shell has been fully bent, while maintaining said fluid pressure.

2. A method as claimed in claim 1 in which the shell comprises a thermoplastic material, said shell being maintained at a temperature at which it is rigid during winding and raised to a temperature at which it is non-rigid during bending.

3. A method as claimed in claim 1 in which the shell comprises a permanently non-rigid material, said shell being supported during winding by a rigid former which is removed prior to bending the shell.

4. A method as claimed in any of claims 1 to 3 in which the shell is bent by applying a turning moment to each end.

5. A method as claimed in any of claims 1 to 4 in which the curable plastics material is heat curable and the pressurising fluid is maintained at the curing temperature of said material at least during the curing operation.

6. A method as claimed in claim 2 in which the pressurising fluid is maintained at a temperature at which the shell is non-rigid at least during the bending operation.

7. A method substantially as hereinbefore described with reference to and as shown in the drawing accompanying the provisional specification.

8. A bent tube of helically wound fibre-reinforced plastics material produced by a method as claimed in any of claims 1 to 7.

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